Measurements of Boundary Thermal Resistance between Thin Films Using the Picosecond Thermoreflectance Method

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The boundary thermal resistance between thin films has been observed for the first time by the rear face heating / front face detection type (RF type) picosecond thermoreflectance method developed in the National Research Laboratory of Metrology. A metal thin film is heated by a picosecond laser pulse through a transparent substrate and the temperature change at the front surface is detected with the thermoreflectance method. This configuration is essentially the same as the laser flash method, which is the standard measuring method of the thermal diffusivity of bulk materials. The thermal diffusivity can be calculated from the heat diffusion time across the film and the film thickness with small uncertainty.

Four types of metallic thin films, Al, Mo, Al/Mo two-layer, Al/Mo/Al/Mo four-layer, are synthesized on the Pyrex glass substrate by the magnetron dc sputtering method. All films have almost the same total thickness of 100 nm. Shapes of thermoreflectance signals of these four thin films measured with the RF type picosecond thermoreflectance method are similar with the rear surface temperature change of bulk specimens measured with the laser flash method.

Although the overall thickness of each film is almost the same, the apparent thermal diffusivity of the two-layer thin film is smaller than the Al thin film and the Mo thin film. Furthermore, the apparent thermal diffusivity of the four-layer thin film is much smaller than the other three thin films.

The boundary thermal resistance is calculated as R(Al/Mo) = 4.1 x 10^{-10} $W^{-1}m^2K$, whereas the thermal resistance of the aluminum thin film is R(Al 50 nm) = 2.1 x 10^{-10} $W^{-1}m^2K$ and that of the molybdenum thin film of 50 nm thickness is R(Mo 50 nm) = 3.6 x 10^{-10} $W^{-1}m^2K$.